APPENDIX K
DEVELOPMENT OF SITE-SPECIFIC STANDARDS
AOI 8: SUNOCO PHILADELPHIA REFINERY
PHILADELPHIA, PENNSYLVANIA

Based on the current and future intended non-residential site use, an exposure assessment was conducted for all compounds in surficial soil (0-2 feet) which exceeded the nonresidential direct contact statewide health standards in AOI 8. Potential human health exposures for the Refinery are evaluated for an industrial worker scenario.

Direct contact exposure pathways to surface soil, groundwater, and LNAPL is for the industrial scenario because of Sunoco's established excavation procedures, PPE requirements and soil handling procedures, as they are described in Appendix K of the 2004 Current Conditions Report (CCR). However, because direct contact to surface soils could occur outside of excavation activities, shallow soil samples were collected in AOI 8 to further evaluate this pathway under a non-residential (on-site worker) scenario.

Based on the recent characterization data collected, concentrations of benzene naphthalene, benzo(a)pyrene, and lead were detected above the non-residential soil MSCs in surficial soil (0-2 feet). In accordance with Section IV of the PADEP's Technical Guidance Manual (TGM) (dated June 8, 2002), the COCs listed above were further screened against the EPA Region III Risk-Based Concentrations (RBCs) (aka, EPA Regional Screening Levels) for industrial soil to potentially reduce the list of compounds carried through the risk assessment.

For all compounds that exceed both the non-residential statewide health standards and EPA Region III RBCs, site-specific standards were calculated using PADEP default intake parameters for an on-site worker and, where appropriate, a risk level of 10^{-4}. For calculating a site-specific standard for on-site workers exposed to lead, Sunoco used the Society of Environmental Geochemistry and Health (SEGH) model used by PADEP to develop the non-residential MSC. The input parameters used to develop the site-specific standards for benzene and lead are provided in Tables K-1 through K-4.

The site-specific standards for the organic compounds (calculated in Tables K-1 through K-4) are as follows:

Compound	Calculated Site-Specific Standard (mg/kg)
Benzene	2,160
Naphthalene	56,780
Benzo(a)pyrene	109
Lead	1,708

The site-specific screening level for benzene was calculated for inhalation based on the calculation specified in 25 Pa. Code § 250.307(b), and for naphthalene and benzo(a)pyrene for ingestion based on the calculations specified in 25 Pa. Code § 250.306(b). These calculations used the PADEP's default parameters and an updated target risk level of 1E-4, in consideration of the site-specific conditions (PADEP's default target risk level is 1E-5).

As presented in Table K-1 through K-4, based on the revised target risk level, the derived site-specific standards for benzene, naphthalene and benzo(a)pyrene are calculated for an onsite worker and are consistent with the values used in the previous Act 2 reports submitted for the Refinery. Concentrations of benzene, naphthalene and benzo(a)pyrene detected in the surface soil samples collected in AOI 8 are below the site-specific standards and, therefore, risk to an on-site worker due to exposure is considered to be within the acceptable Act 2 range.

The site-specific screening level for lead was calculated for ingestion. As presented in 25 Pa. Code § 250.306(e), Appendix A, Table 7, the non-residential soil screening value for lead is based on the method presented in the report 'The Society for Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil' (Wixson, 1991). The model used by the PADEP and developed by SEGH was also used to calculate the site specific criterion for the refinery. Based on the SEGH model and PADEP's default parameters, PADEP's non-residential direct contact MSC default value for lead in surface soil is 1,000 mg/kg. To develop a site-specific criteria for lead,

some of the parameters used by the PADEP were updated in consideration of site-specific conditions and updated lead data collected from recent studies. These parameters are discussed in the following paragraphs.

Target blood lead concentration (T) – The default target blood lead concentration used by the PADEP to develop the non-residential MSC is 20 ug/dL; however, the Center for Disease Control (CDC) recommends that worker blood lead levels be maintained below 25 ug/dL (NIOSH, 2008) to prevent adverse health effects for most workers from exposure to lead throughout a working lifetime. Based on conversations between representatives of Sunoco and EPA, the target lead blood level identified by the CDC is used in the site-specific calculation in Tables F-4 and F-5.

Geometric mean background blood lead concentration (B) – B is the background blood lead concentration in the target population from sources other than soil and dust. The PADEP's default value for B is 4 ug/dL and, as summarized in PADEPs reference document (Wixson, 1991), is based on data gathered in the United Kingdom from young children. The US Center for Disease Control and Prevention (CDC) in Atlanta, GA has monitored blood lead levels in US children and adults since 1976 and, based on the most recent results published by the National Center for Environmental Health of the CDC (NCEH, 2005), the mean blood lead concentration for an adult 20 years of age or older is 1.56 ug/dL. Based on the more recent study by the US CDC, the value used for B in the site specific calculation has been revised to 1.56 ug/dL.

CONCLUSIONS

As presented in Table K-4, based on the revised parameters, the derived site-specific standard for lead in soil is 1,708 mg/kg for a refinery worker. Concentrations of lead detected in the surface soil samples collected in AOI 8 are below the site-specific standard and, therefore, risk to an on-site worker due to exposure to lead is considered to be within the acceptable Act 2 range.

In addition to calculating the site-specific standards for benzene, naphthalene,

Table K-1
Derivation of Site-Specific Soil Value
for Benzene[1]
AOI 8 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source
Transport Factor	TF	13,100	mg/kg / mg/m^3	25 Pa. Code § 250, Appendix A Table 5
Absorption	Abs	1	unitless	25 Pa. Code § 250.307(d)
Exposure Time	ET	8	hr/day	25 Pa. Code § 250.307(d)
Exposure Frequency	EF	180	d/yr	25 Pa. Code § 250.307(d)
Target Risk[2]	TR	0.0001	mg/kg	
Inhalation Cancer Slope Factor	CSF_I	0.027	mg/kg-day^{-1}	25 Pa. Code § 250, Appendix A Table 5
Averaging Time for Carcinogens	AT_C	70	yr	25 Pa. Code § 250.307(d)
Inhalation Factor	IF_{ADJ}	0.4	unitless	25 Pa. Code § 250.307(d)

Site-Specific, Non-Residential (Onsite Worker) Screening Value **2,160** **mg/kg**

Notes:

1. The site specific screening value was calculated for inhalation based on the calculation specified in 25 Pa. Code 250.307(b)(1)

$$MSC\ (mg/kg) = \frac{TR \times AT_C \times 365\ days/year \times TF}{CSF_I \times Abs \times ET \times EF \times IF_{ADJ}}$$

2. The target risk level was modified from PADEP's default (1E-5) to 1E-4.

Table K-2
Derivation of Site-Specific Soil Value
for Naphthalene[1]
AOI 8 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source
Target Health Quotient	TR	1		25 Pa. Code § 250.306(d)
Oral Reference Dose	RfD_o	0.02	$mg/kg\text{-}day^{-1}$	25 Pa. Code § 250, Appendix A Table 5
Body Weight	BW	70	kg	25 Pa. Code § 250.306(d)
Averaging Time	AT_{DC}	25	yr	25 Pa. Code § 250.306(d)
Absorption	Abs	1	unitless	25 Pa. Code § 250.306(d)
Exposure Frequency	EF	180	d/yr	25 Pa. Code § 250.306(d)
Exposure Duration	ED	25	yr	25 Pa. Code § 250.306(d)
Conversion Factor	CF	1.00E-06	kg/day	25 Pa. Code § 250.306(d)
Ingestion Rate	IngR	50	mg/day	25 Pa. Code § 250.306(d)

Site-Specific, Non-Residential (Onsite Worker) Screening Value **56,780** **mg/kg**

Notes:

1. The site specific screening value was calculated for ingestion based on the calculation specified in 25 Pa. Code 250.306(b)

$$MSC\ (mg/kg) = \frac{THQ \times RFDo \times BW \times AT_{DC} \times 365\ days/year}{Abs \times EF \times ED \times IngR \times CF}$$

Table K-3
Derivation of Site-Specific Soil Value
for Benzo(a)pyrene[1]
AOI 8 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source
Absorption	ABS	1	unitless	25 Pa. Code § 250.306(d)
Exposure Frequency	EF	180	d/yr	25 Pa. Code § 250.306(d)
Conversion Factor	CF	1.00E-06	kg/day	25 Pa. Code § 250.306(d)
Target Risk[2]	TR	1.00E-04	mg/kg	
Oral Cancer Slope Factor	CSF_o	7.3	$mg/kg\text{-}day^{-1}$	25 Pa. Code § 250, Appendix A Table 5
Averaging Time for Carcinogens	AT_c	70	yr	25 Pa. Code § 250.306(d)
Ingestion Factor	IFadj	17.9	mg-yr/kg-day	25 Pa. Code § 250.306(d)

Site-Specific, Non-Residential (Onsite Worker) Screening Value **109** **mg/kg**

Notes:

1. The site specific screening value was calculated for ingestion based on the calculation specified in 25 Pa. Code 250.306(b)

$$MSC\ (mg/kg) = \frac{TR \times AT_C \times 365\ days/year}{CSF_O \times Abs \times EF \times IF_{ADJ} \times CF}$$

2. The target risk level was modified from PADEP's default (1E-5) to 1E-4.

Table K-4
Derivation of Site-Specific Soil Value
for Lead[1]
AOI 8 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source[2]
Blood lead target concentration	T	25	ug/dL	CDC - ABLES (NIOSH, 2008)
Geometric standard deviation of the blood lead distribution	G	1.4	unitless	25 Pa. Code § 250, Appendix A Table 7
Background blood lead concentration in the population from sources other than soil or dust	B	1.56	ug/dL	NCEH Pub. No. 05-0570 (NCEH, 2005)
Number of standard deviations corresponding to the degree of protection required for the population at risk	n	1.645	unitless	25 Pa. Code § 250, Appendix A Table 7
Response of the blood lead versus soil lead relationship	δ	7.5	ug/dL blood / ug/g soil	25 Pa. Code § 250, Appendix A Table 7

Site-Specific, Non-Residential (Onsite Worker) Screening Value **1,708** **ug/g (mg/kg)**

Notes:

1. The site specific screening value for lead was calculated for ingestion based on the SEGH model as specified by 25 Pa. Code 250.306(e)

$$MSC\ (mg/kg) = \frac{[(T/G^{n}) - B] \times 1000}{\delta}$$

2. Sources for blood lead target level (T) based on conversation between James Oppenheim of Sunoco and Hon Lee of EPA in November 2010.

NIOSH (2008). Adult Blood Lead Epidemiology and Surveillance (ABLES). http://www.cdc.gov/niosh/topics/ABLES

NCEH (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Laboratory Sciences. Atlanta, Georgia. NCEH. Pub. No. 05-0570.

Table K-5
Summary of Site Specific Cumulative Risk Evaluation
AOI 8 Site Characterization/Remedial Investigaiton Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

				Benzene (71-43-2)		Naphthalene (91-20-3)		Benzo(a)pyrene (50-32-8)		Lead (7439-92-1)	
Location ID	Sample ID	Sample Interval	Sample Date	Reported Result (mg/kg)	Calculated Risk	Reported Result (mg/kg)	Calculated Hazard Quotient	Reported Result (mg/kg)	Calculated Risk	Reported Result (mg/kg)	Blood Lead Concentration[4] (ug/dL)
BH-08-01	BH-08-01_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	ND	--	69.7	3.6
BH-08-02	BH-08-02_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	138	4.5
BH-08-03	BH-08-03_1.0-2.0	1.0-2.0	5/7/2008	0.58	2.69E-08	ND	--	ND	--	291	6.5
BH-08-04	BH-08-04_1.0-2.0	1.0-2.0	5/8/2008	3.3	1.53E-07	12	0.00021	ND	--	829	13.5
BH-08-07	BH-08-07_1.0-2.0	1.0-2.0	5/8/2008	1.4	6.51E-08	15	0.00026	ND	--	519	9.5
BH-08-08	BH-08-08_1.0-2.0	1.0-2.0	5/7/2008	1.9	8.83E-08	ND	--	ND	--	637	11.0
BH-08-09	BH-08-09_1.0-2.0	1.0-2.0	5/7/2008	3.2	1.49E-07	5.9	0.00010	ND	--	262	6.1
BH-08-10	BH-08-10_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	2.6	2.39E-06	428	8.3
BH-08-11	BH-08-11_1.0-2.0	1.0-2.0	5/7/2008	0.31	1.44E-08	ND	--	ND	--	131	4.4
BH-08-12	BH-08-12_1.0-2.0	1.0-2.0	5/6/2008	3.1	1.44E-07	2.7	0.00005	ND	--	1250	19.0
BH-08-13	BH-08-13_1.0-2.0	1.0-2.0	5/6/2008	ND	--	ND	--	1.3	1.20E-06	314	6.8
BH-08-14	BH-08-14_1.0-2.0	1.0-2.0	5/6/2008	ND	--	ND	--	ND	--	78.8	3.7
BH-08-15	BH-08-15_1.0-2.0	1.0-2.0	5/6/2008	ND	--	ND	--	ND	--	22.8	3.0
BH-08-16	BH-08-16_1.0-2.0	1.0-2.0	5/7/2008	3.1	1.44E-07	18	0.00032	ND	--	1380	20.7
BH-08-17	BH-08-17_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	102	4.0
BH-08-18	BH-08-18_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	22.2	3.0
BH-08-21	BH-08-21_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	540	9.8
BH-08-22	BH-08-22_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	213	5.5
BH-08-23	BH-08-23_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	374	7.6
BH-08-24	BH-08-24_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	172	5.0
BH-08-25	BH-08-25_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	223	5.6
BH-08-26	BH-08-26_1.0-2.0	1.0-2.0	5/8/2008	9	4.18E-07	ND	--	ND	--	261	6.1
BH-08-27	BH-08-27_1.0-2.0	1.0-2.0	5/6/2008	ND	--	ND	--	0.4	3.68E-07	89.7	3.9
BH-08-28	BH-08-28_1.0-2.0	1.0-2.0	5/6/2008	ND	--	ND	--	ND	--	132	4.4
BH-08-29	BH-08-29_1.0-2.0	1.0-2.0	5/6/2008	ND	--	ND	--	ND	--	96.4	4.0
BH-08-31	BH-08-31_1.0-2.0	1.0-2.0	5/6/2008	ND	--	ND	--	11	1.01E-05	1300	19.7
BH-08-32	BH-08-32_0.0-2.0	0-2.0	7/3/2008	ND	--	ND	--	0.9	8.29E-07	128	4.4
BH-08-33	BH-08-33_1.5-2.0	1.5-2.0	5/6/2008	ND	--	0.36	0.00001	3.6	3.31E-06	172	5.0
BH-08-34	BH-08-34_1.5-2.0	1.5-2.0	5/6/2008	ND	--	ND	--	29	2.67E-05	354	7.3
BH-08-35	BH-08-35_1.0-2.0	1.0-2.0	5/6/2008	ND	--	ND	--	ND	--	14.3	2.9
N-98	N-98_1.0-2.0	1.0-2.0	6/2/2008	ND	--	1	0.00002	ND	--	94.5	3.9
N-99	N-99_1.0-2.0	1.0-2.0	6/17/2008	ND	--	53	0.00093	61	5.62E-05	146	4.6
N-100	N-100_0.0-2.0	0.0-2.0	6/11/2008	ND	--	ND	--	ND	--	135	4.5
N-101	N-101_1.0-2.0	1.0-2.0	6/16/2008	ND	--	ND	--	ND	--	78.1	3.7
N-102	N-102_1.0-2.0	1.0-2.0	6/5/2008	ND	--	ND	--	0.2	1.84E-07	24.7	3.0
N-103	N-103_1.0-2.0	1.0-2.0	6/6/2008	ND	--	ND	--	ND	--	174	5.0
N-104	N-104_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	ND	--	164	4.9
N-105	N-105_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	ND	--	36.4	3.2
N-106	N-106_1.0-2.0	1.0-2.0	6/5/2008	ND	--	ND	--	0.19	1.75E-07	76.7	3.7
N-107	N-107_1.0-2.0	1.0-2.0	6/17/2008	0.74	3.44E-08	ND	--	ND	--	173	5.0
N-108	N-108_1.0-2.0	1.0-2.0	5/29/2008	ND	--	ND	--	5.4	4.97E-06	147	4.6
N-109	N-109_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	ND	--	294	6.5
N-110	N-110_1.0-2.0	1.0-2.0	5/14/2008	ND	--	ND	--	ND	--	15	2.9
N-111	N-111_1.0-2.0	1.0-2.0	5/14/2008	ND	--	ND	--	ND	--	117	4.2
N-112	N-112_1.0-2.0	1.0-2.0	5/8/2008	ND	--	ND	--	ND	--	11.6	2.9
N-113	N-113_1.0-2.0	1.0-2.0	5/15/2008	ND	--	ND	--	ND	--	77.9	3.7
N-114	N-114_1.0-2.0	1.0-2.0	5/8/2008	0.51	2.37E-08	ND	--	ND	--	139	4.5
N-115	N-115_0.0-2.0	0.0-2.0	5/28/2008	ND	--	ND	--	6.5	5.98E-06	1250	19.0
N-116	N-116_1.0-2.0	1.0-2.0	5/20/2008	ND	--	ND	--	ND	--	340	7.1
N-117	N-117_1.0-2.0	1.0-2.0	6/4/2008	ND	--	ND	--	0.63	5.80E-07	219	5.6
N-118	N-118_1.0-2.0	1.0-2.0	5/23/2008	ND	--	ND	--	ND	--	200	5.3
N-119	N-119_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	0.43	3.96E-07	101	4.0
N-120	N-120_1.0-2.0	1.0-2.0	5/22/2008	ND	--	ND	--	ND	--	181	5.1
N-121	N-121_1.0-2.0	1.0-2.0	6/9/2008	ND	--	ND	--	ND	--	64	3.5
N-122	N-122_1.0-2.0	1.0-2.0	5/7/2008	ND	--	ND	--	ND	--	207	5.4
N-123	N-123_1.0-2.0	1.0-2.0	5/20/2008	ND	--	ND	--	13	1.20E-05	254	6.0
N-124	N-124_1.0-2.0	1.0-2.0	5/21/2008	ND	--	ND	--	ND	--	43.9	3.3
N-125	N-125_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	1.5	1.38E-06	150	4.7
N-126	N-126_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	ND	--	912	14.6
N-127	N-127_1.0-2.0	1.0-2.0	5/22/2008	ND	--	ND	--	ND	--	191	5.2
N-128	N-128_1.0-2.0	1.0-2.0	5/20/2008	1.9	8.83E-08	2.2	0.00004	6	5.52E-06	61.4	3.5
N-129	N-129_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	ND	--	31.3	3.1
N-130	N-130_0.0-2.0	0.0-2.0	5/16/2008	ND	--	ND	--	ND	--	670	11.5
N-131	N-131_1.0-2.0	1.0-2.0	6/17/2008	ND	--	ND	--	ND	--	88.8	3.9
N-132	N-132_1.0-2.0	1.0-2.0	5/13/2008	ND	--	ND	--	ND	--	94.9	4.0
N-133	N-133_1.0-2.0	1.0-2.0	5/15/2008	3.7	1.72E-07	ND	--	ND	--	865	14.0
N-134	N-134_1.0-2.0	1.0-2.0	5/22/2008	ND	--	4.7	0.00008	37	3.41E-05	74.6	3.7
N-135	N-135_1.0-2.0	1.0-2.0	5/15/2008	ND	--	2.1	0.00004	1.5	1.38E-06	273	6.3
N-136	N-136_1.0-2.0	1.0-2.0	5/15/2008	0.7	3.25E-08	ND	--	ND	--	320	6.9
			Cumulative Total:	***1.55E-06***		***2.06E-03***		***1.68E-04***			

Maximum Total Cumulative Risk for Carcinogens: **1.69E-04** *> 1 in 10,000*
Maximum Hazard Index for Non-Carcinogens: **0.0021** *< 1*

Notes:
ND - Not Detected Above Lab Reporting Limit
(1) All soil samples collected and analyzed were unsaturated.
(2) all samples are located outside SWMU areas.
(3) Maximum Total Cumulative Risk is the combined risk of exposure to the detected concentrations of carcinogenic compounds benzene and BaP and should be less than 1 in 10,000.
(4) Calculated based on site specific parameters provided in Table F-4. The CDC (NIOSH, 2008) recommends that blood lead levels be maintained below 25 ug/dL.